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THE FREQUENCY OF USE AND COST OF SELECTED ANESTHETIC INDUCTION AND NEUROMUSCULAR BLOCKING AGENTS

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ABSTRACT

The purpose of this study was to identify the most frequently used agents for induction and neuromuscular blockade for intubation, and to identify variables which affected these choices. Anesthetic records (n=77) were obtained to examine the frequency of use of induction agents and neuromuscular blockers. Anesthesia care providers completed a survey (n=19) which provided information on induction and neuromuscular relaxation agent preferences, factors influencing their choices, and estimated costs of anesthesia induction and neuromuscular relaxation drugs. Cost estimates were compared to published costs of selected anesthesia drugs. The average cost of each of four combinations of induction and neuromuscular relaxation agents was compared to the average PACU time. Propofol was found to be the most frequently used agent for induction (75.3%). Succinylcholine was chosen most often for use as a neuromuscular relaxation agent (98.7%). The three most important factors influencing the choice of either agent was the physical status of the patient, the incidence of side effects produced by the drug, and the duration of action of the drug. Patients who received propofol had a shorter PACU stay (x=92.3 minutes) than those patients who received sodium thiopental (x=110.5 minutes). The estimated cost for propofol/succinylcholine per patient was $11.16 versus $2.38 for sodium thiopental/ succinylcholine. Based on a cost of $8.12 per minute for PACU care, the cost savings was estimated to be $139.00 for a patient who received propofol/succinylcholine compared to a patient who received sodium thiopental/succinylcholine.

FREQUENCY OF USE AND COST OF SELECTED ANESTHETIC INDUCTION AND NEUROMUSCULAR BLOCKING AGENTS

By

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THESIS

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DEDICATION

I dedicate the completion of this thesis to God, because with God all things are possible. I also dedicate this thesis to my loving family. I thank you all for your continued support, love, and encouragement. A sincere thank you goes to Trevor for being there through all of the late nights and long hours.

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CHAPTER ONE : INTRODUCTION

Background of the Problem

The health care industry has grown tremendously over the years. Growth has been accompanied by an increase in the complexity of the health care field as well as increased choices and increased costs. Health care expenditures in the United States for 1992 was $809 billion (Antebi & Ornstein, 1994).

Health care costs are continuing to climb and the health care industry is continually trying to institute effective cost containment measures. A balance between cost and health care has yet to be achieved.

Canadian researchers report anesthesia drug expenditures as being approximately 10% of a hospital's drug budget (Horrow & Rosenberg, 1994). In the United States, anesthesia drugs constitutes a significant fraction of the monies spent on health care. The cost of anesthesia drugs was estimated to be $700 million in 1992 (Antebi & Ornstein, 1994). Market researchers are projecting sales of anesthesia drugs to reach $2.1 billion by 1999 (Gannon, 1993). Because of this projected rapid increase in expenditures, it is important to examine the relationship between anesthesia drug choice and anesthesia drug cost.

Many anesthesia drugs are available for use by anesthesia providers, and myriad factors must be considered when deciding which ones to use. Gone are the days when choosing a drug was based solely on results of risk-benefit studies. Affordability must be placed high on the list of priorities when considering acquiring additional drugs (Antebi & Ornstein, 1994).

Previous studies have attempted to look at anesthetic choice. Katz (1973) and Broadman, Mesrobian, and McGill (1987) researched anesthetic choice among anesthesiologists. Dewan and Rosenberg (1988) researched anesthetic choice among nurse anesthetists. Although these studies yielded valuable information about the personal choice of anesthesia care providers for regional anesthesia versus general anesthesia, they did not address preference for various intravenous anesthesia drugs.

Stanek (1996) attempted to identify the choice of intravenous induction agents and intubation neuromuscular blockers by anesthesia providers at a military hospital. Data were collected through the use of a provider interview and chart review questionnaire. American Society of Anesthesiologists (ASA) I and II patients were included with ages ranging from 18 to 69. Review of the anesthetic records and analysis of interview data revealed a clear preference for propofol as the induction agent and succinylcholine as the neuromuscular blocking agent for intubation. There was no difference in the choice of agents related to years of anesthesia practice.

Several studies have addressed anesthesia drug cost. Johnstone and Jozefczyk (1994) retrospectively identified the most frequently used anesthesia drugs and studied the effect of a cost education program on the use of the ten most expensive drugs. Anesthesia drugs chosen for the study were atracurium, vecuronium, midazolam, dobutamine, human plasma protein fraction, sufentanil, propofol, amrinone, mivacurium, and alfentanil. There was a reduction in use of the more expensive drugs for two months. Subsequently, the use of these drugs climbed above preeducation levels. Horrow and Rosenberg (1994) studied the effect of placing price stickers on drugs and its impact on the pattern of use. Pancuronium, vecuronium, and succinylcholine were the

most frequently used neuromuscular blocking agents before and during the pricing period. Thiopental was the most frequently used hypnotic agent. Their study "demonstrated no substantive effect of cost sticker placement on the usage of either neuromuscular blocking agents or rapidly-acting sedative-hypnotic agents" (p.1051). Neither of the studies addressed the how or why of anesthesia drug selection.

Clinical decision making concerning choice of anesthesia drug may be the result of cumulative knowledge from "previous experience, information obtained from continuing medical education endeavors, peer-reviewed literature, advertisements, pharmaceutical industry representatives; patient factors, including anticipated complications; convenience and expediency; and cost" (p.1047). With such an extensive list, it is not difficult to realize why the cost factor has not been highlighted in previous literature.

Unfortunately, the cost of anesthetic drugs can no longer be considered inconsequential. The simplistic system of anesthesia provider choosing the anesthesia drug and the patient paying the bill is changing (Antebi & Ornsten, 1994). Health care consumers are demanding "quality health care at a reasonable cost" (Suver, Arikian, Doyle, Sweeney, & Hagan , 1995, p.561). "In today's health care settings, an anesthesia provider needs to be able to explain the use of individual agents based on advantages and costs to the patient and the institution" (Stanek, 1996, p. 40). Health maintenance organizations have quadrupled in number over the last ten years (Sheperd & Salzman, 1994). Their goal is "to deliver quality health care while containing costs" (Suver et al., 1995, p.561).

Tight fiscal management will undoubtedly lead to decreases in agents available

for use by anesthesia care providers. Currently, it is unclear what provider preferences are for the various agents or how cost effects preference. Furthermore, providers may be unaware of the cost of various drugs. Through identification of frequently used anesthetic induction and neuromuscular blocking agents, research can be conducted to generate data about choices made by anesthesia care providers. These data can then be analyzed to examine the cost incurred for providing anesthesia care using each agent.

It is unknown how anesthesiologists make their selections of anesthetic techniques and anesthesia drugs from among choices with widely varying costs (Johnstone & Jozefczyk, 1994). Very rarely is information on the cost or cost effectiveness of new drugs included in scientific papers found in anesthesiology literature (Antebi & Ornstein, 1994). "The economic realities of health care and anesthesia require the inclusion of costs when considering any benefits found in a scientific study" (Johnstone & Martinec, 1993, p.196).

Therefore, the purpose of this study is (a) to identify the most frequently used agents for induction and neuromuscular blockade for intubation, and (b) to identify variables which affect these choices. A relatively new avenue using current clinical practice data will be used to conduct this pharmacoeconomic study of anesthesia drugs (Wagner & O'Hara, 1995). A descriptive correlational study design is used to investigate this problem.

Rational and Significance of the Problem

"To control department drug expenses, anesthesiology directors must know how and why practitioners make specific drug selections and how cost information alters their

selections" (Johnstone & Jozefczyk, 1994, p.766). Although cost is not the only factor to consider in anesthesia drug choice, it is increasing in importance.

Cost containment is the wave of the future. Because it is becoming such a vital piece of the health care finance puzzle, it is important to investigate the impact cost has on anesthesia drug choice. It is also important to understand what other factors contribute to anesthesia providers drug selection choices.

"Surgical outcomes and their related costs have become of great interest in recent years, not only because of a general interest in improving patient care but also because adverse outcomes increase costs" (Wagner & O'Hara, 1995, p.773). If it is known which agents are used and the factors that influence the decision making, measures can be instituted to promote the use of agents that are clinically beneficial and also cost effective. Likewise, agents that do not contribute to overall quality care and cost reduction can be deleted from the formulary or have their use significantly curtailed.

Cost containment strategies undertaken by health maintanance organizations, hospitals, and governments seek to decrease costs. Little attention is given to the overall cost-benefit of various pharmacological agents. Ignoring this very valuable area of information may lead to acquisition of drugs that may be inexpensive initially, but increase the overall cost associated with its use (i.e., increased length of stay in the recovery room) (Suver et al., 1995). Research should include cost effectiveness analysis (Antebi & Ornstein, 1994) because it "provides a basis for informed clinical decision making" (Joshi, 1995, p.1251).

Both civilian and military health care administrators are becoming increasingly concerned about the spiraling costs of health care. The civilian sector, in

great measure, has moved towards a framework of health maintenance organizations, with the primary goal of providing affordable, quality care to its members while generating a profit for the organization (Sheperd & Salzman, 1994). The military has instituted Tricare. Tricare is the military equivalent of a civilian managed-care health care program. The program is managed by the military and is a partnership with civilian health care providers. The program is financed by enrollment fees and taxpayer dollars from the military health budget (Lamar, 1994). Monies saved from anesthesia drug costs in the military sector can be diverted into other areas of the hospital to foster an increase in number of services, personnel, and resources. This would decrease overall costs to patients and taxpayers by decreasing the amount of services needed through other avenues such as Tricare.

Statement of the Problem

There have been no correlation of variables effecting provider choices about the frequency of use of selected drugs for anesthetic induction and neuromuscular relaxation for intubation. The factors that influence the choice of agents for induction and neuromuscular relaxation for intubation are unknown.

Research Questions

1. What is the frequency of use of specific agents used for induction of anesthesia and neuromuscular relaxation for intubation in ASA class I and II patients?
2. What are the most influential factors identified by providers that effect the choice of agents used for induction and neuromuscular relaxation for intubation in ASA class I and II patients?
3. Are anesthesia care providers aware of cost differences between selected

induction and neuromuscular blocking agents?

4. Do patients who receive propofol have a shorter post anesthesia care unit (PACU) stay than patients who receive sodium thiopental?

Definition of Terms

Induction of anesthesia: The process by which the loss of sensation is initiated by an intravenous pharmacological agent that produces a state of unconciousness.

Neuromuscular relaxation for intubation: A state of muscle paralysis produced by blocking nerve to muscle transmission through the neurotransmitter acetylcholine at the cholinergic nicotinic receptor as a result of the use of a depolarizing or nondepolarizing intravenous pharmacological agent.

Anesthesia care provider: a licensed physician with specialty training in the field of anesthesia or a registered nurse with specialized education in the field of anesthesia who has successfully completed the certification examination administered by the American Association of Nurse Anesthetists.

American Society of Anesthesiologists (ASA) Class I: "The patient has no organic, physiologic, biochemical, or psychiatric disturbance. The pathologic process is localized and does not entail a systemic disturbance" (Waugaman, Foster, & Rigor, 1992, p.188).

ASA Class II: "The patient has a mild to moderate systemic disturbance caused by either the conditions to be treated surgically or other pathophysiologic process. (Example: controlled hypertension)" (p.188).

Limitations

1. Agents used are limited by those available at the institution.
2. There is no established reliability with the tools used for this research study.
3. The study is conducted at one hospital, therefore, results can not be generalized.
4. Recovery room logbook entries do not specify which certified registered nurse anesthetist provided care for the case.
5. Anesthesiologists do not routinely provide anesthesia care for a case as the sole anesthesia care provider.
6. Biased sample of persons agreeing to participate in the study.

Assumptions

1. The identified agents are the ones most frequently used.
2. Questionnaires will be answered truthfully.

CHAPTER TWO : LITERATURE REVIEW

Review of the Literature

Various anesthetic drugs are available for the induction of anesthesia. The ideal intravenous anesthetic induction agent has favorable pharmacokinetic and physiochemical properties such as water solubility, stability in light, a shelf life of greater than one year, and requires only a small volume for induction of anesthesia. Further, the ideal induction agent would have small interindividual variations, a high therapeutic index, a quick onset of action, a short duration of action, a rapid recovery, and would be rapidly metabolized to inactive end products. The ideal agent would have no histamine release and would not produce anaphylaxis. Finally, the ideal agent would have minimal or no adverse side effects (Barash, Cullen, & Stoelting,1992; Geniton, 1992).

The ideal induction agent does not exist. Two agents, sodium thiopental and propofol, are used frequently because of their favorable properties. "The supremacy of the barbiturates for intravenous induction of anesthesia has remained virtually unchallenged since the introduction of thiopental by Lundy in 1934" (Stoelting, 1991, p.108). Thiopental is a thiobarbiturate. It was synthesized in 1929 and used clinically in 1934 (Waugaman et al., 1992).

Thiopental is a derivative of barbituric acid formed by substitution of sulfur at the number two carbon position on the parent molecule (Stoelting, 1991; Waugaman et al., 1992). It acts by depressing the reticular activating system as it enhances the inhibitory action of gamma-aminobutyric acid (GABA) by binding to the GABA A receptor (Stoelting, 1991; Katzung, 1995). Thiopental is considered an ultra short acting induction agent with onset within one arm-brain circulation time (ten to twenty seconds)

(Waugaman et al.,1992). It is highly lipid soluble which accounts for its rapid plasma:brain equilibration (approximately one minute) and redistribution (Waugaman et al., 1992; Katzung, 1995).

Thiopental is considered cerebral protective. It causes cerebral vasoconstriction, decreases intracranial pressure, decreases cerebral oxygen demand, and raises the seizure threshold (Geniton, 1992). Thiopental causes dose-dependent respiratory depression and has been implicated as a causative agent in bronchospasm secondary to histamine release with rapid intravenous administration. Although thiopental may cause cardiac depression, it is rarely a problem with dosages used for induction.

Thiopental is metabolized by the liver and its inactive metabolites are excreted by the kidneys. It is rapidly redistributed from tissues in the vessel rich group and uptake continues at adipose tissue and skeletal muscle. Consciousness returns rapidly (three to ten minutes), but sedation may be prolonged as a result of slow plasma clearance (three to eight hours).

Thiopental provides a smooth induction and is pleasant for the patient. It provides amnesia, but no analgesia. It may also produce unwanted side effects which includes psychomotor impairment, nausea and vomiting.

Thiopental has a long history of use in the United States. It is considered safe in clinical doses, and is inexpensive, which makes it an attractive choice for an induction agent. Propofol (2,6-diisopropylphenol) is a phenol derived ultra-short acting nonbarbiturate induction agent. Although used widely in Europe in the 1980s, its use in the United States was delayed until 1989. Propofol is lipid soluble and therefore has a rapid onset of thirty to sixty seconds (Stoelting, 1991; Szneke, 1989). It is thought to

exert its action by enhancing the GABA-activated chloride ion channel function of GABA A receptors through a separate recognition site on the receptor or by some other mechanism (Barash et al., 1992).

Propofol is not cerebral protective even though it decreases cerebral oxygen demand, decreases intracranial pressure, and decreases cerebral blood flow. Propofol decreases systemic blood pressure which causes a decrease in cerebral perfusion pressure, thus creating a situation in which ischemia may develop. Propofol, like thiopental, causes a dose-dependent respiratory depression. Propofol may cause a 15% to 30% decrease in arterial blood pressure resulting from decreased systemic vascular resistance (Geniton, 1992). This drop in blood pressure is lessened with intubation as propofol does not completely block the hypertensive and catecholamine response that occurs (Brossy, James, & Janicki, 1994). Propofol was found to more effectively attenuate the hypertensive response to intubation in infants (Schrum et al., 1994).

Propofol's rapid metabolism to inactive metabolites, which exceeds hepatic blood flow, suggests extrahepatic as well as hepatic removal of the drug from the plasma (Stoelting, 1991; Geniton, 1992). This rapid metabolism translates into a prompt emergence within two to eight minutes (Geniton, 1992; Katzung, 1995). Propofol has an elimination half-life of one to three hours (Katzung, 1995).

Propofol provides for smooth induction, has antiemetic properties, and allows earlier post operative ambulation (Geniton, 1992; Katzung, 1995). There is less incidence of post operative shivering when compared to thiopental (Singh, Harwood, Cartwright, & Crossley, 1994). Patients report they feel better during the immediate post

operative period after receiving propofol (Katzung, 1995). Propofol does not produce amnesia (Kashtan & Mallon, 1990). The pharmacodynamic and pharmacokinetic properties of propofol make it a good choice for use in outpatient surgery (Geniton, 1992; Katzung, 1995).

Propofol produces side effects which are primarily the consequence of reactions to the vehicle in which propofol is dissolved. Sepsis, as a result of microorganism growth in the propofol emulsion, has been reported. The potential exists for an allergic reaction in any persons with a known egg allergy caused by the use of egg lecithin to prepare the emulsion (Geniton, 1992). Pain may be experienced upon injection of propofol (Stoelting, 1991).

In a comparison of induction and recovery characteristics for thiopental and propofol, Weightman and Zacharias (1987) found no significant differences in the induction using these agents. However, pain on injection and fall in systolic blood pressure were noted with propofol. Anesthesia was maintained using these agents by administering doses of the drugs from within a specified range. No other volatile or analgesic agents were used. Postoperative recovery was measured by several objective signs, which included the return of the eyelash reflex and patients' ability to state their date of birth. Propofol afforded a much faster recovery than thiopental, as well as a more rapid return of psychomotor function. These findings are consistent with those discovered by other researchers (Kashtan & Mallon, 1990; Sanders, Clyburn, Rosen, & Robinson, 1991; Weightman & Zacharias, 1987; Doss et al., 1994).

"The introduction of propofol has brought us one step closer to the ideal agent" (Geniton, 1992, p.1566). It's major drawback may be the cost of the drug. "New drugs

usually cost more than established drugs" (Johnstone & Jozefczyk, 1994, p. 766). A cost of $2.77 was reported to induce a 70 kg patient using a dose of 4mg/kg of thiopental as compared to $18.10 using propofol at 2.5 mg/kg. "The least expensive drug may not ultimately yield the least expensive care" (Horrow & Rosenberg, 1994, p. 1052). Even though propofol is more expensive, its positive properties may make it a better choice for the induction of anesthesia.

Discussion surrounding the selection and evaluation of induction agents are rivaled by discussions of which agent to use for neuromuscular blockade during tracheal intubation. "Succinylcholine is the only depolarizing neuromuscular blocking drug used clinically in the USA" (Katzung, 1995, p.410). It is one of the few drugs which has enjoyed sustained popularity for forty years despite its associated complications (Bevan, 1994). Its neuromuscular blocking effects were not noted until 1949 (Waugaman et al., 1992; Stoelting, 1991). It was used clinically in 1951 in Europe and in 1952 in the United States (Waugaman et al., 1992).

Succinylcholine is the only neuromuscular blocking agent with a rapid onset (usually within one minute), short duration of action (five to ten minutes) (Barash et al.,1992; Katzung, 1995) and rapid spontaneous recovery (Bevan, 1994). It is completely and rapidly hydrolyzed by plasma cholinesterase (pseudocholinesterase) which terminates its action (Stoelting, 1991; Barash et al., 1992; Waugaman et al., 1992; Hoshi, Hashimoto, & Matsukawa, 1993). It is comprised of two molecules of acetylcholine linked through the acetate methyl groups (Katzung, 1995; Stoelting, 1991). Acetylcholine is the neurotransmitter at the cholinergic nicotinic neuromuscular junction. When acetylcholine binds to the two alpha subunits of the postjunctional cholinergic

nicotinic receptor, the postjunctional membrane is depolarized causing muscle activity (Stoelting, 1991).

Succinylcholine exhibits acetylcholine-like action and causes depolarization in a fashion similar to that of acetylcholine. Because it is broken down slower than acetylcholine, its action at the receptor is prolonged leading to a state of lack of responsiveness of the receptor or desensitization (Barash et al., 1992). The net effect is inhibition of muscle activity because the depolarized membrane can not respond to acetylcholine released subsequent to succinylcholine administration (Stoelting, 1991).

Succinylcholine may cause hyperkalemia, increased intraocular pressure, increased intragastric pressure in association with fasciculations, muscle pain, and increased intracranial pressure (Katzung, 1995; Barash et al., 1992; Waugaman et al., 1992; Stoelting, 1991; Schweinefus & Schick, 1991). Succinylcholine's effect at cardiac cholinergic muscarinic receptors may cause cardiac dysrrhythmias. A junctional bradycardia is more likely to occur when a second dose of the drug is administered within five minutes of the first dose (Barash et al.,1992; Waugaman et al., 1992; Stoelting, 1991; Katzung, 1995). With low doses, negative inotropic and chronotropic responses are elicited. Positive inotropic and chronotropic responses occur with large doses (Katzung, 1995).

"Succinylcholine has been incriminated as the trigger of allergic reactions more often than any other intravenous drug used in anesthesia" (Barash et al., 1992, p.484). It does have a low potential for producing histamine release that is clinically significant. However, true anaphylaxis is rare (Waugaman et al., 1992).

Abnormal muscle responses to succinylcholine may accompany rare underlying

muscle conditions (i.e, myotonia congenita) or develop in the presence of a hypermetabolic state in individuals genetically sensitive to it. Masseter muscle rigidity and malignant hyperthermia are two such manifestations (Stoelting, 1991; Waugaman et al., 1992; Bevan, 1994). Usual doses (1mg/kg) of succinylcholine may cause prolonged paralysis of three to six hours in patients who are homozygous for abnormal plasma cholinesterase, a variance in the enzyme that is genetically determined (Barash et al., 1992; Waugaman et al.,1992; Schweinefus & Schick, 1991). A boxed warning is found in the package insert for succinylcholine that cautions against the routine use of the drug in pediatrics and adolescents because of the potential for immediate cardiac arrest in children with occult myopathies (Book, Abel, & Eisenkraft, 1994; Bevan, 1994).

"Succinylcholine has enjoyed a unique role in clinical anesthesia. Despite its many potential complications and drug interactions, it will remain in clinical use until a nondepolarizing muscle relaxant with rapid onset and a duration of action profile similar to that of succinylcholine is introduced" (Waugaman et al., 1992, p.489).

Atracurium besylate is an intermediate acting, bisquarternary ammonium benzylisoquinolone, nondepolarizing neuromuscular blocking agent. It was synthesized by Stenlake and his colleagues in an effort to formulate a short acting agent whose degradation was independent of hepatic or renal metabolic pathways (Barash et al.,1992; Waugaman et al., 1992). It was used initially in 1979 (Waugaman et al., 1992). Atracurium structurally resembles acetylcholine (Katzung, 1995) which allows it to exert its action by acting as a competitive antagonist to acetylcholine. It prevents acetylcholine from interacting with the cholinergic nicotinic receptor, and thus, it prevents depolarization and muscle activity (Katzung, 1995).

Atracurium is inactivated by Hoffman elimination (in vivo, nonenzymatic, spontaneous degradation at body pH and temperature) and ester hydrolysis by nonspecific esterases (Waugaman et al., 1992; Stoelting, 1991; Katzung, 1995). The rate of degradation via Hoffman elimination slows with a pH of less than 7.4 and temperature less than 37°C. This is in contrast to the rate of degradation by ester hydrolysis which is increased by decreases in pH to less than 7.4 (Stoelting, 1991). The most significant metabolites of atracurium are laudanosine and quarternary monoacrylate.

Atracurium is prepared as an iodide salt, besylate, which provides water solubility and adjusts the pH to 3.25 to 3.65 to minimize the incidence of spontaneous in vitro degradation. Its potency decreases by approximately 5% every 30 days when stored at room temperature. If stored under refrigeration at 5°C, potency decreases 6% per year (Waugaman et al., 1992).

Atracurium possesses dose-dependent onset time and duration of action. Using ED95 doses, onset is four minutes with a duration of forty-four minutes (Conner, 1984; Basta, 1982). Because atracurium is considered a possible substitute for succinylcholine during intubation, attempts have been made to speed its onset. Hilgenberg (1983) reported an onset of 1.7 minutes using twice the ED95 (0.4mg/kg) with Basta (1982) reporting a duration of 63.5 minutes at that dose. Naguib, Abdulatif, & Gyasi (1987) noted 0.5mg/kg (2.5 ED95) to be the maximum dose not associated with significant histamine release. Payne and Hughes (1981) used 0.6mg/kg in their study to produce good intubating conditions with complete block within one minute. There was no noted histamine release.

The priming principle using 10% of the intubating dose has been demonstrated to

speed the onset of neuromuscular blockade by Naguib et al. (1987), and Mehta, Choi, & Sokol (1985). However, Davison and Holland (1989) found no difference in onset time using a priming dose. The discrepancy may lie in the time span between administration of the priming dose and administration of the remaining portion of the dose. Davison and Holland used five minutes as opposed to three minutes used in the earlier studies.

As a nondepolarizing neuromuscular blocking agent, atracurium inhibits transmission at the nicotinic cholinergic and muscarinic sites and parasympathetic and sympathetic nicotinic ganglia. Cardiovascular changes with atracurium are transient and may be associated with histamine release. These changes are related to the rate of administration and total dose (Waugaman et al., 1992). Doses of up to twice the ED95 produce no blood pressure and heart rate changes (Stoelting, 1991). Administering a dose of three times the ED95 rapidly increases heart rate 8.3% and decreases mean arterial pressure 21.5% (Waugaman et al., 1992; Stoelting, 1991).

Atracurium possesses two quarternary nitrogens. This makes it poorly lipid soluble and prevents its entry into the central nervous system (Katzung, 1995). Laudanosine, a metabolite inactive at the neuromuscular junction, crosses the blood-brain barrier and is implicated as a cause of cerebral excitement and seizures (Barash et al., 1992; Stoelting, 1991). "However, in clinical practice, degradation of atracurium does not appear to yield quantities of laudanosine that cause central nervous system (CNS) excitement" (Lien, Belmont, Kopman, & Savarese, 1993, p.739).

The potency and effective doses of atracurium are similar for adults and children. Infants, age one to six months, require approximately one half of the dose given to older children (Stoelting, 1991).

Atracurium is non organ dependent for degradation and elimination. This makes it a good choice for use in patients with hepatic or renal failure (Lien et al., 1993). Fahey, Rupp, & Canfell (1985) reported increased levels of laudanosine in anephric patients, but noted that levels achieved did not reach the toxic range documented in animal studies.

Atracurium has the potential for acting as a substitute for succinylcholine for rapid sequence induction. It can produce good intubating conditions at one minute with doses of 0.6mg/kg (three times ED95). Unfortunately, this dose is associated with increasingly significant cardiovascular changes, histamine release, and a duration of action of 75.7 minutes (Basta, 1982).

Vecuronium bromide is a "monoquarternary steroidal analogue of pancuronium" (Stoelting, 1991, p. 204). It is classified as an intermediate acting neuromuscular blocking agent. Vecuronium was developed in an effort to provide a neuromuscular blocking agent with fewer cumulative and cardiovascular effects, rapid onset and shorter duration of action, and less dependence on renal and hepatic function for elimination. (Conner, 1984).

Vecuronium undergoes a limited amount of spontaneous deacetylation to three alcohol metabolites. It is primarily excreted unchanged in the bile and in the urine (Conner, 1984; Lien et al., 1993). The major metabolite is less than one tenth as potent as the parent compound (Stoelting, 1991).

Vecuronium, like atracurium, possesses a does-dependent onset time and duration of action. A dose of 0.05mg/kg (1 ED95) has an onset time of 4 minutes (Waugaman et al., 1992). Hilgenberg (1983) reported an onset of 2.4 minutes with a dose of 2 ED95. Onset time decreases to 1.1 minute with a dose of 5 ED95 (Waugaman et al., 1992).

The priming principle using 10% of the intubating dose has been demonstrated to speed the onset of neuromuscular blockade. Time to intubation with vecuronium using the priming principle is under 1.5 minutes (Waugaman et al., 1992).

In a study by Wierda et al. (1995), the time required to achieve adequate muscle relaxation for intubation was studied. Sixty ASA I - II patients, ages 18 - 65 years, were involved in the study. Twenty patients were assigned to each of the three categories to receive either vecuronium, rocuronium, or mivacurium as the neuromuscular blocking agent for intubation. Intubation attempts were performed at 90 seconds. Excellent intubating conditions at 90 seconds were achieved with 6 patients (30%) receiving vecuronium, 16 patients (80%) receiving rocuronium, and 5 patients (25%) receiving mivacurium. Dosages of vecuronium, rocuronium, and mivacurium used for the study were 0.1 mg/kg, 0.6 mg/kg, and 0.16 mg/kg respectively. At these dosages, the clinical duration was 33 minutes for vecuronium, 28 minutes for rocuronium, and 13 minutes for mivacurium.

Davison and Holland (1989) compared the use of vecuronium and atracurium for rapid sequence induction. Succinylcholine was used in the control group. Patients in the control group received d-tubocurarine as a pretreatment followed by 2 mg/kg of succinylcholine. The patients in the other two groups received a priming dose of the drug to be used consisting of 10% of the intubating dose followed by the intubating dose.

The time to 80 - 90% neuromuscular block was significantly faster with succinylcholine. No difference in time to 80 - 90% neuromuscular block was noted between vecuronium and atracurium. Intubating conditions were essentially the same among all three groups at 80 - 90% neuromuscular blockade.

The overall class of steroidal neuromuscular drugs has not been associated with histamine release. Naguib, Samarkandi, Bakhamees, Magboul, and El-Bakry (1995) compared histamine release and hemodynamic changes associated with various benzylisoquinolinium (i.e., atracurium, mivacurium, d-tubocurarine) and steroidal (i.e., rocuronium, vecuronium) neuromuscular blocking drugs. There was no significant hemodynamic changes or changes in plasma histamine concentrations with vecuronium.

In the search to discover the ideal nondepolarizing muscle relaxant to allow rapid control of the airway, rocuronium bromide has been formulated. Rocuronium is a monoquarternary aminosteroid derivative of vecuronium (Plaud et al., 1995). It is classified as a short acting nondepolarizing neuromuscular blocking agent with a dose-dependent onset and duration of action (Organon, 1995). At a dose of 0.6mg/kg it has an onset of one and a half minutes and duration of action of thirty minutes. Increasing the dose to 0.9 mg/kg speeds its onset to forty-five seconds with fifty minutes duration (Mirakhur, 1994). Naguib (1994) demonstrated an onset time of seventy-three seconds and duration of thirty-nine minutes when using a priming dose of 10% of the total intubating dose (0.06mg/kg) followed three minutes later with the remaining intubating dose (0.54mg/kg). This time was shortened to fifty-eight seconds with 36.8 minutes duration using mivacurium 0.015mg/kg as the priming dose followed by rocuronium 0.54mg/kg. Cooper, Mirakhur, Clarke, & Boules (1992) found excellent to good intubating conditions at sixty to ninety seconds which were comparable to intubating conditions found with the use of succinylcholine without using a priming technique. Rocuronium's dose response is comparable for adults and children (Lien et al., 1993). It, like atracurium and vecuronium, inhibits nerve transmission at the

muscarinic and nicotinic cholinergic sites as well as parasympathetic and sympathetic nicotinic ganglia.

Rocuronium is primarily excreted by the hepatobiliary route. Because of its primary route of elimination, it should be used with caution in patients with significant hepatic disease or extrahepatic biliary obstruction, as the duration of action may be prolonged (Organon, 1995; Wicks, 1994; Duke & Rosenberg, 1996). Khalil et al. (1994), in a study of eighteen male patients did note a prolonged recovery with the use of rocuronium in patients with cirrhosis. They attributed this slight prolongation to an initial increased volume of distribution and concluded that the pharmacodynamics and pharmacokinetics of rocuronium were not influenced by liver failure. In contrast, Magorian et al. (1991) demonstrated a significant difference in duration of action in patients with hepatic dysfunction using the same intubating dose (0.6 mg/kg). Approximately 33% of the drug is excreted unchanged in the urine (Wierda et al., 1991). The use of moderate doses of rocuronium in patients with renal failure is safe. Onset, clinical duration, and recovery from neuromuscular blockade is not significantly altered (Lien at al., 1993).

Rocuronium is not associated with any significant cardiovascular effects or histamine release (Mirakhur, 1994). Naguib et al. (1995) examined histamine release and its effect on heart rate and arterial pressure in seventy ASA I or II patients with respect to the administration of rocuronium, vecuronium, d-tubocurarine, mivacurium, and atracurium. 200% to 300% increases in plasma histamine levels were noted with d-tubocurarine 0.5mg/kg, mivacurium 0.2mg/kg, and atracurium 0.6mg/kg. Increased heart rate and decreased arterial pressure were observed. No significant histamine release

or hemodynamic changes were noted with vecuronium 0.1mg/kg or rocuronium 0.6mg/kg.

The search for an ideal muscle relaxant continues. The rapid onset and short duration of succinylcholine has not been exceeded by any nondepolarizing neuromuscular blocking agent. Atracurium may be used, but it like succinylcholine may produce histamine release. Atracurium and vecuronium have an onset of two to three minutes which makes them less suitable for rapid sequence induction. The addition of rocuronium to the armamentarium has taken us one step closer to finding a substitute for succinylcholine. It has a rapid onset. Unfortunately, it has an intermediate duration of action and has organ dependent elimination.

Conceptual Framework

In studying the frequency of use of an anesthetic drug, it is necessary to understand what impacts the provider's choice of drug. Decisions about the use of anesthesia drugs are not made arbitrarily. Making health decisions involves "identifying the options; identifying the possible outcomes of each option; evaluating the evidence that relates the options to the outcomes; estimating the consequences of each option; weighing the benefits of each option against harms and costs; factoring in a variety of logistic, economic, legal, social, and personal considerations; and choosing the option that is in some sense the 'best' " (Eddy, Feb 9, 1990b, p.877).

Eddy (Jan 19, 1990a) postulated that there are two main steps to making a decision, analysis and judgements. In the first step, evidence and information on alternative options are collected and analyzed with regard to benefits, harms, and cost.

The second step is based on the outcomes from the processes used in the first step. Judgements are made based on comparisons of (a) possible harms such as inconvenience,

side effects, risks, and anxiety, (b) health outcomes in relation to costs, and (c) benefits gained compared to resources consumed to determine what choices produce the highest yield.

Clinicians evaluate available options constantly. Unfortunately, the cost factor in decision making is not taken into account as frequent. Cost benefit analysis must be included in present day decision making. Anesthesia care providers must be able to perform cost benefit analysis in order to keep up with the changing face of health care financing. "Drug costs may be one of the areas that is more amenable to immediate cost reduction in an anesthesia department budget" (Vitez, 1994, p.362).

Tuman (1995) advocates the use of outcome data to reduce costs and improve efficiency (Figure 1). Outcome research is needed for the development of practice guidelines which would contribute to a more productive health care economy. There must be documented evidence supporting the benefit of altering current practice. It is believed that patient care has improved through the use of certain monitors, drugs, or anesthetic techniques. Unfortunately, there is a lack of reported measures of quality.

In the present atmosphere of rising health care costs, there is a demand for proof of value. Research on practice variations and inappropriate care can assist in proving the value of current anesthetic practices as well as aid the development of outcome measures for future studies.

The measurement outcomes can then provide feedback for additional outcomes to be investigated as well as provide the necessary information for education of providers. As providers examine patterns of providing anesthesia care, practice guidelines can be developed to delete those practices that are cost inefficient and advocate those that are

cost beneficial. The result would be lower costs, greater efficiency, reduced variation, and improved outcomes.

The outcome measures to be used for this study are selected direct and indirect costs of anesthetic drugs. When comparing the overall cost-benefit of various drugs, direct and indirect costs must be considered. The direct cost included is the cost to acquire the drug. The indirect cost to be investigated is the occurrence of postoperative complications contributing to extended recovery room stay.

Intelligent decision making requires extensive analysis of clinical benefit. In the current climate of cost containment and managed care, the decision making process is not complete without the vital element of cost-benefit analysis.

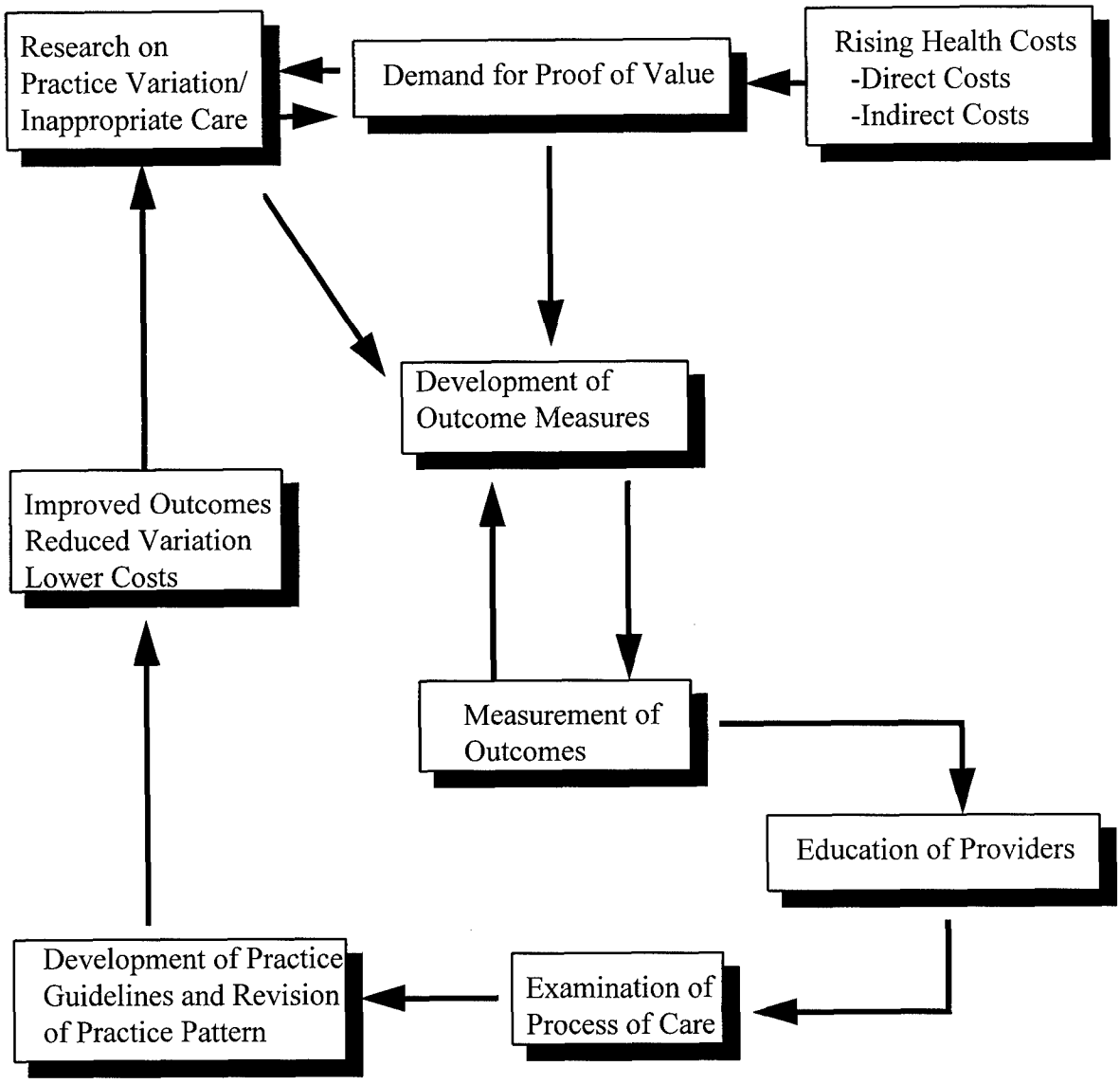

Figure 1.
Use of Outcome Data to Improve Efficiency and Reduce Costs

Tuman, K.J. (1995). Cost containment and efficiency in perioperative care. In P.G. Barash (Ed.), The American Society of Anesthesiologists, Inc. (Vol 23, pp. 231-246). Philadelphia: Lippincott - Raven Publishers.

CHAPTER THREE : METHODOLOGY

Research Design

A descriptive correlational survey research design was used to investigate the frequency of use and cost of selected anesthetic induction and neuromuscular blocking agents. The primary purpose of the research was to examine or describe the relationship that exists between anesthesia care providers' choice of induction and neuromuscular blocking agents and the two variables of frequency of use and cost. No attempt was made to control or manipulate the variables (Burns & Grove, 1993). A retrospective chart review and anesthesia provider questionnaire were used.

There are weaknesses associated with the correlational survey design. The independent variable can not be manipulated, participants can not be randomly assigned to groups, and the data obtained is usually without depth. The results obtained using this research design may lead to misinterpretation of the results. Cause and effect relationships can not be inferred with this design. This type of design is usually costly in terms of personnel time and resources (Polit & Hungler, 1987).

The strengths associated with this design includes an efficient means of collecting a large amount of information with efficacy, it can be applied to many different populations under investigation, and it can be used for many different purposes. This research design is strong in the area of presenting a realistic view of the topic under investigation, and for this reason, it appeals to many researchers when they seek to find solutions to practical problems.

Threats to the internal validity of this research design such as history, maturation statistical regression, and mortality were not of concern. All of the information was

collected at one time instead of over a period of time. The questionnaires were given to the participants with written instructions. The questionnaires were returned to the researcher. There was a threat from instrumentation. The instruments used were without established reliability or validity. Interviews were not used for this study. The effect of testing did not pose a threat because the study did not use a pre- and post-test. (Burns & Grove, 1993).

There was the threat of selection. The accepting sample was the group that agreed to participate in the study after the sample was selected by the researcher. This led to a somewhat biased sample of persons agreeing to participate in the study. Their motives for agreeing to participate may be suspect (Polit & Hungler, 1987).

The Hawthorne effect was a threat to the external validity of this research design. The participants may in fact have altered their responses on the questionnaires secondary to their participation in the study. To a lesser degree, measurement effects may have affected the external validity of the design. The use of a questionnaire versus an interview would most likely affect the responses given by two different groups of participants. A pilot study was not used. Overall, the research design for this study was sound and appropriate for the question being investigated.

Sampling and Sampling Technique

The target population was anesthesia care records from all licensed staff anesthesia care providers employed by a 300 bed inner city community hospital performing approximately 3000 surgeries a year. The post anesthesia care unit (PACU) log book was to be used to obtain the name of the physician anesthesia care provider and as a guide to obtaining the name of the nurse anesthesia provider. It was also to be used

to obtain the patient name and other identification information in order to obtain the medical records. In examining the PACU log book, it was noted that the log book did not contain adequate information and thus it was not used for the study.

Data was obtained by reviewing approximately 1000 anesthetic records chosen from six randomly selected months from the previous year. The last ten records per provider meeting the inclusion criteria were chosen. The records reviewed were from the care of ASA class I and II patients, ages 18 to 61 years, undergoing general anesthesia requiring endotracheal intubation.

Questionnaires were distributed to all twenty five anesthesia care providers. The response rate was 76%. Generally there is a 25-30% response rate with mailed questionnaires. A 70% response rate was expected. A post card follow up and second survey distribution helped to increase the response rate (Burns & Grove, 1993). Follow up was done at four, six, and eight weeks from the initial survey distribution.

Quota sampling was used for obtaining the anesthesia care records to ensure the inclusion of records that met the outlined criteria. Convenience sampling was used for selection of anesthesia care providers to participate in the study. Neither type of sampling allowed for control of bias.

Ethical Considerations

In an effort to protect the human rights of the subjects and institutions involved, confidentiality and privacy were safeguarded. The research proposal was subject to administrative review by the Institutional Review Board (IRB) secondary to it being categorized as exempt.

A cover letter was sent to all participants. The cover letter included a brief

description of the research being conducted, notification that participation was voluntary and participants may withdraw at any time, a statement of the potential benefits and risks, an explanation of procedures, a statement of the time involved to complete questionnaires, a statement ensuring confidentiality, information as to how to obtain study results, and information as to how to contact the researcher if any questions. Participants gave their consent by virtue of completing the questionnaire.

An agency request for cooperation was sent to the institution. It included a statement of the purpose of the study, a statement about the subjects involved and how they were chosen, a statement of the time involved, a statement of how study results can be obtained, and a statement ensuring confidentiality.

Subjects were asked for demographic information. This information was not be linked to any particular participant. Anonymity was assured for this study.

Instrumentation

The instruments selected for use in this study were an anesthesia care provider questionnaire and retrospective chart review questionnaire adapted from questionnaires used initially by a nursing graduate student. The questionnaires appeared to have face and content validity. Two experienced anesthesia care providers reviewed the items on the questionnaires. They felt as though the items measured the frequency with which anesthesia care providers chose intravenous agents for induction and neuromuscular relaxants for intubation, and reasons for the choices made.

Directions for completion of the anesthesia provider questionnaire were clear. The statements were objective. There was no tendency to sway the respondent towards a particular response. However, the questionnaire may not have been completely unbiased.

Respondents may have interpreted the given responses as suggestive of anticipated answers. The respondent was provided an opportunity to write in responses which may have decreased some of the potential bias. The chart review questionnaire was clear, objective, and concise.

The anesthesia provider questionnaire took approximately 15 to 30 minutes to complete. It was easily read and written clearly and simply. The questionnaire was easy to administer.

The chart review questionnaire took approximately 15 to 30 minutes to complete. It was also easily read and easy to use.

There was no established reliability with either instrument. The instruments have face and content validity as determined by two experienced anesthesia care providers. A study was conducted using the original instruments. However, the instruments used for this study are adaptations of the original instruments.

Data Collection Procedure

Data was collected using the anesthesia provider questionnaire and the retrospective chart review questionnaire. Both instruments utilized statements instead of questions.

Questionnaires were selected for use because they are practical and efficient. Analysis of data is usually easier with a structural data collection method. Also, the use of this more structural technique aids in decreasing bias that might result from subjective interpretation of data obtained from less structured collection methods (Polit & Hungler, 1987).

Quota sampling was used to obtain the needed number of anesthesia care records.

Convenience sampling was used to obtain the sample of anesthesia care providers. The questionnaires and cover letters were placed in the mailbox of each provider found in the anesthesia office as a package, after consent was obtained from the participating institution. The package was addressed to each individual anesthesia care provider.

A self addressed stamped envelope was provided. The return address space on the envelope contained the institution's address. Incoming questionnaires were then sorted and made ready for data tabulation.

CHAPTER FOUR : RESULTS

Seventy-seven anesthetic records for 10 anesthesia care providers were reviewed for the retrospective chart review. Ten charts for each of seven certified registered nurse anesthetists (CRNAs) were used. Inadequate numbers of anesthetic records were found for three CRNAs because they were recently employed by the institution and/or they were part-time employees. No anesthetic records were found that met the inclusion criteria for anesthesia care provided solely by anesthesiologists. Factors contributing to this finding were recent employment at the institution and/or part-time status for eight of the 14 anesthesiologists. Records that were found for the remaining six anesthesiologists were from obstetrical care or care of emergency patients, both of which were categories excluded in this study.

Patient Characteristics

Sixteen ASA I and 61 ASA II patients were included in the record review. Ages ranged from 18 to 61 years with a mean age of 35 years. 23% were male and 77% were female. Of the surgeries performed, 34% were gynecologic, 32% orthopedic, 13% ENT (ear, nose, throat), and 29% included a variety of surgical categories (Figure2).

Anesthetic Agents Used

In 75% of the cases, propofol was chosen as the induction agent (Figure 3), while succinylcholine was chosen as the neuromuscular relaxation agent in all but one case (Figure 4). There were no significant correlations between choice of induction agent or neuromuscular relaxation agent and the ASA classification, age, or surgical procedure of patients. Significant correlations were found between ASA classification and age in

years (r = .305, p>.01) and type of surgery performed and age in years (r = .243, p>.05) (Table 1).

Propofol was administered to 81% of ASA I patients and 74% of ASA II patients, while sodium thiopental was administered to 19% of ASA I patients and 26% of ASA II patients (Figure 5). Patients received an average propofol dose of 2.5 mg/kg and an average sodium thiopental dose of 4.7 mg/kg. Succinylcholine was dosed at an average of 0.74 mg/kg. The one patient receiving vecuronium was given a dose of 0.13 mg/kg.

Table 1.
Correlation Matrix for ASA Classification, Patient Age, Surgical Procedure and Choice of Anesthetic Agent

	Patient's Age in Years	Patient's ASA Class	Type of Surgery Performed	NMR+ Agent	Induction Agent
Patient's Age in Years	1.000	.305**	.243*	0.128	-0.032
Patient's ASA Class	.305**	1.000	0.188	0.059	-0.070
Type of Surgery	.243*	0.188	1.000	-0.150	-0.183
NMR+ Agent	0.128	0.059	-0.150	1.000	0.066
Induction Agent	-0.032	-0.070	-0.183	0.066	1.000

*.Correlation is significant at the 0.05 level
**.Correlation is significant at the 0.01 level
+NMR agent = neuromuscular relaxation agent

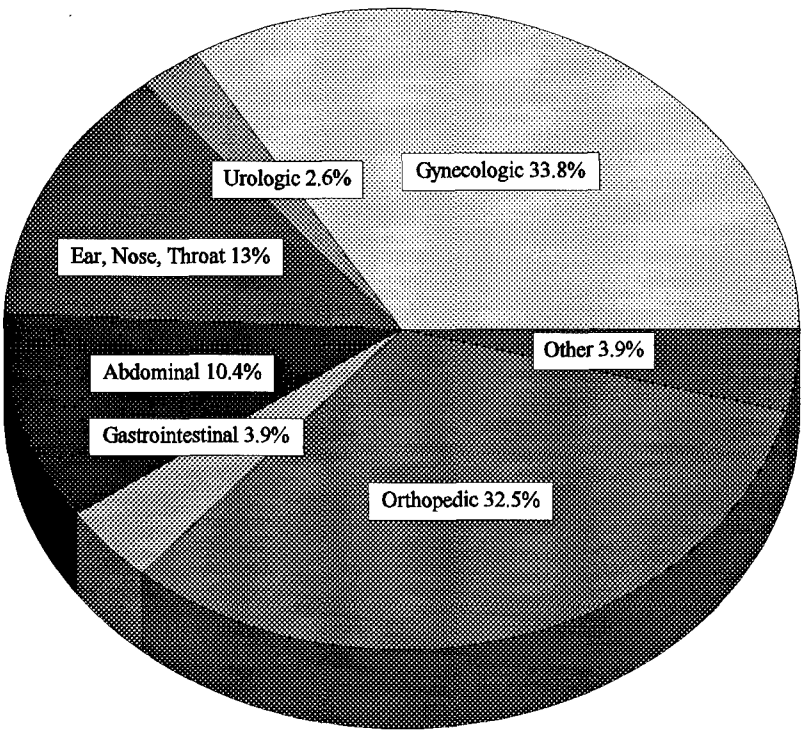

Figure 2.
Categories of Surgeries Performed

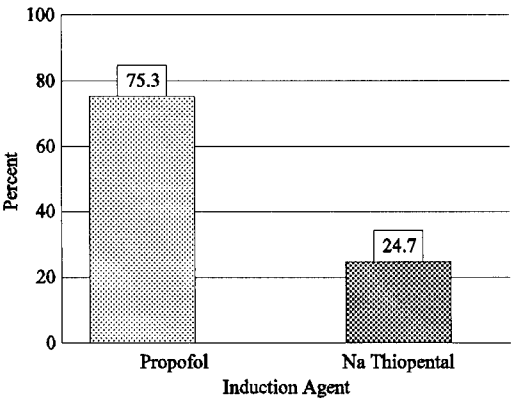

Figure 3.
Induction Agent Used

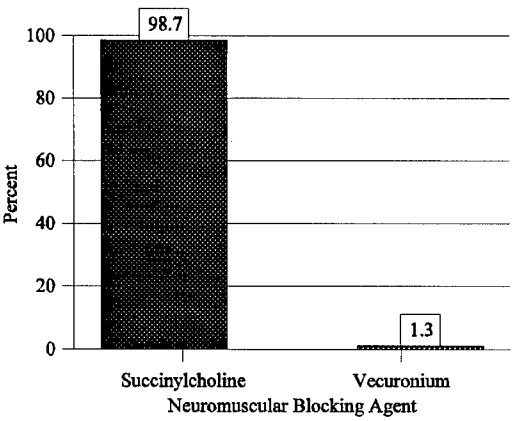

Figure 4.
Neuromuscular Blocking Agent Used

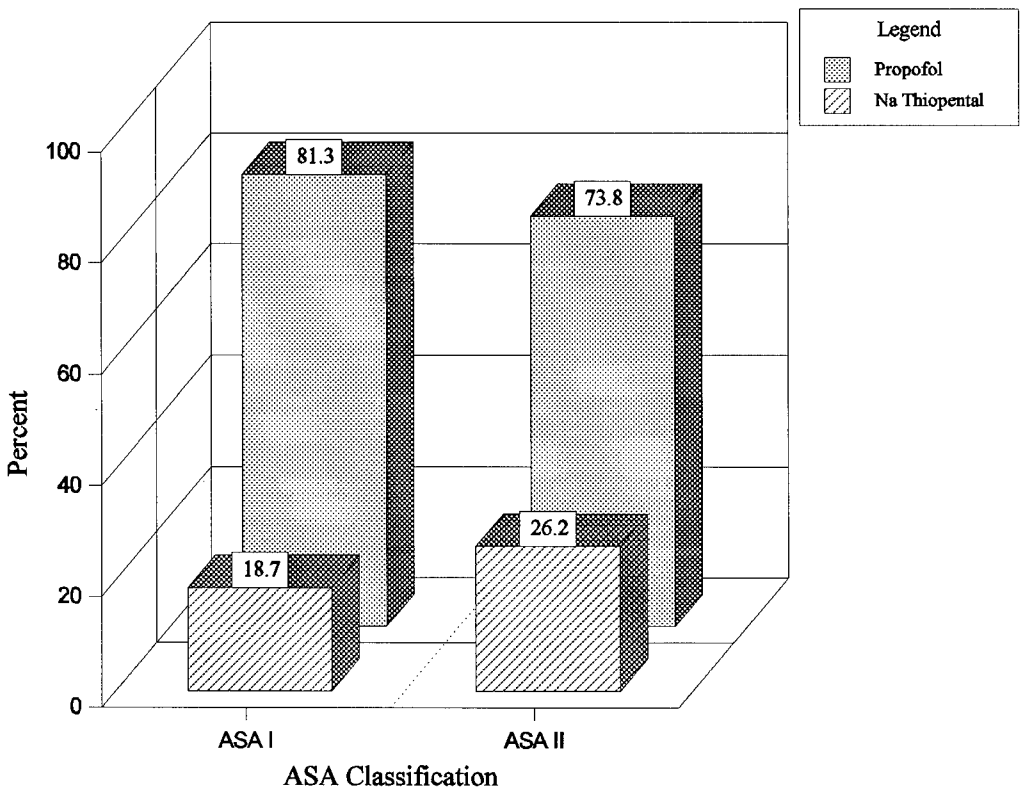

Figure 5.
Induction Agent Used by ASA Classification

Time Spent in the Post Anesthesia Care Unit

The time spent in the post anesthesia care unit (PACU) ranged from 30 to 300 minutes with a mean of 96.8 minutes. The mean PACU time after using sodium thiopental as the induction agent was 110.5 minutes. Patients who received propofol as the induction agent spent an average of 92.3 minutes in PACU (Figure 6).

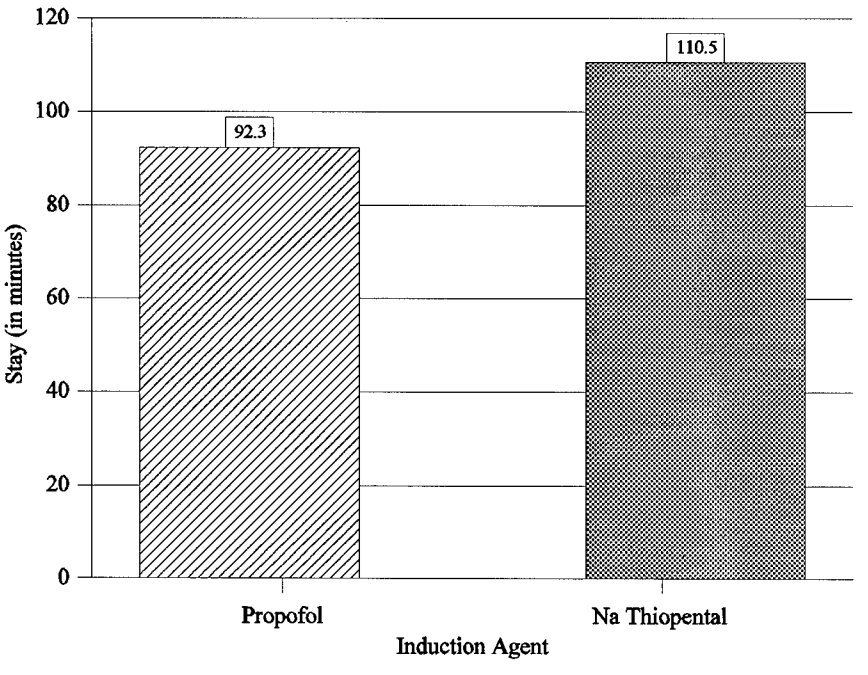

Figure 6.
Average Post Anesthesia Care Unit Stay, by Induction Agent

Complications

A total of 76 postoperative complications were reported for 54 (70%) of the 77 patients in the study. Thus, some patients had multiple complications. The most common postoperative complication was pain, reported by 55% of the patients studied. Nausea and vomiting occurred in 12% of the patients and 12% had decreased temperature (Figure 7).

There was a higher incidence of postoperative complications of any kind with the use of sodium thiopental (79% of the cases) than with propofol (67%) (Figure 8). Conversely, no complications were reported for 33% of the propofol cases compared to 21% for those in which sodium thiopental was used (Figure 9). As Figure 8 shows, the types of complications were comparable for the two induction agents except for the categories, "respiratory difficulties" and "other" which were higher for sodium thiopental.

Choice of Anesthetic Agent

Nineteen anesthesia care providers (CRNA and anesthesiologist) returned surveys. There were eight male and eleven female respondents ranging in age from 30 to 59 years with an average of 11.34 years of anesthesia practice.

Propofol was the first choice of induction agents by 90% of the providers. Sodium thiopental was indicated as the number one choice by 10% of the respondents (Table 2). Second choice consideration was given to sodium thiopental by 77% of the providers, propofol by two (17%) providers, and versed plus a narcotic by one of thirteen (8%) providers. Etomidate was the third choice for an induction agent by 26% of the anesthesia providers.

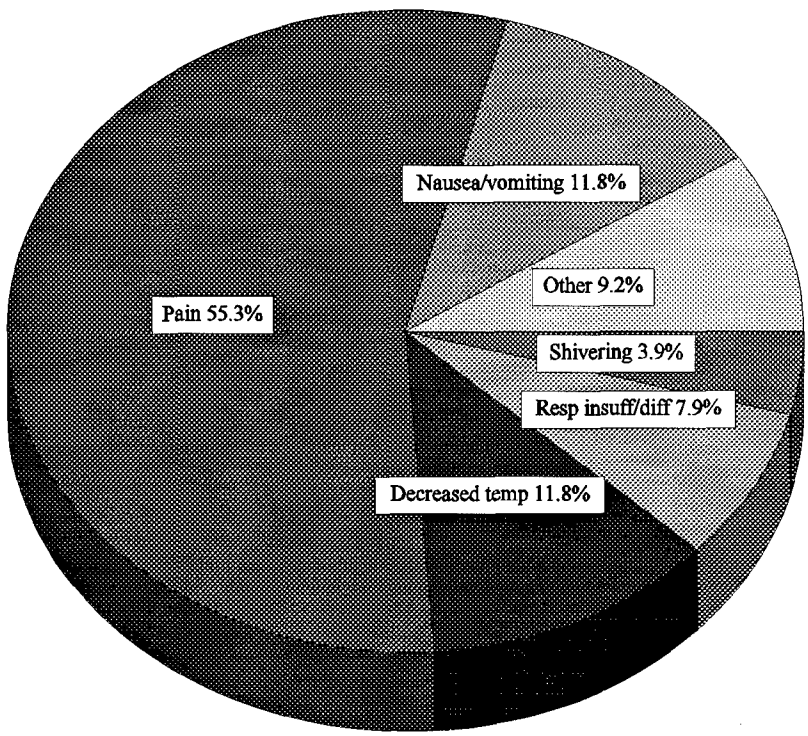

Figure 7.
Percent of Post Op Complications

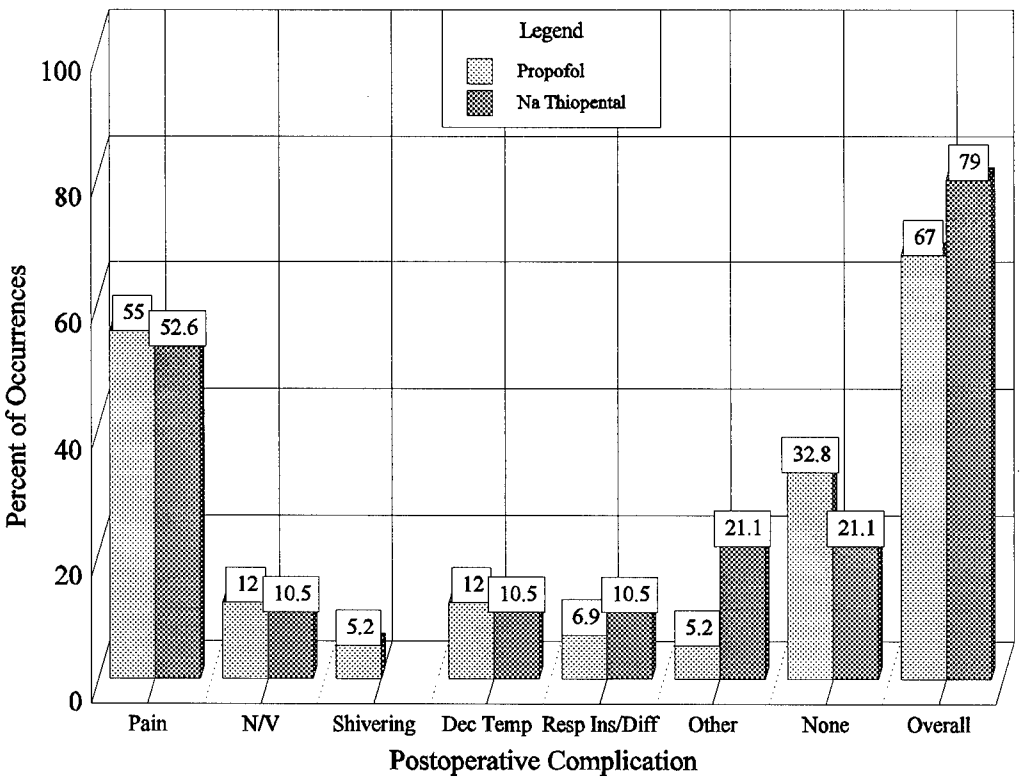

Figure 8.
Incidence of Post Op Complications, by Induction Agent

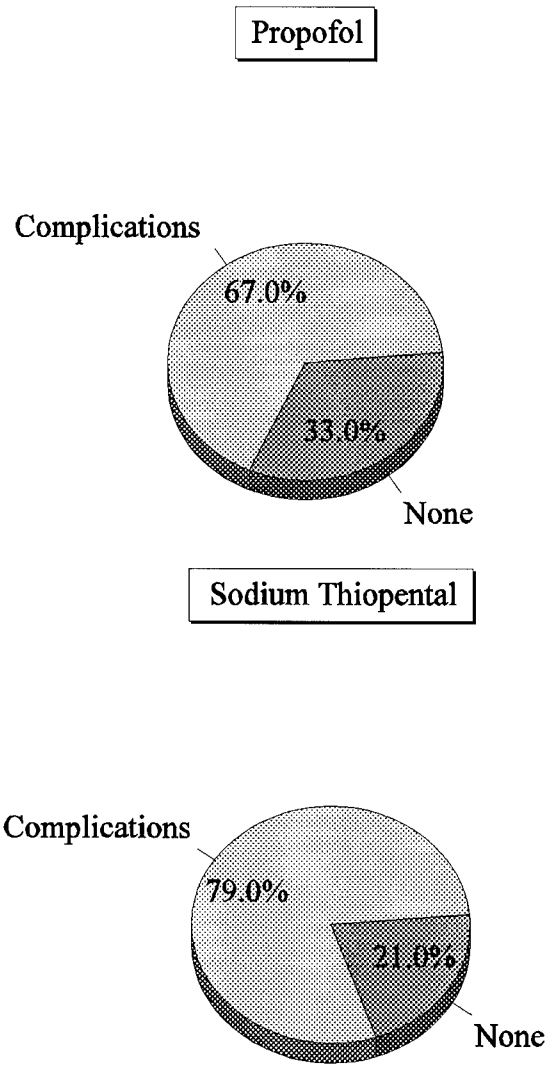

Figure 9.
Occurrence of Complications, by Induction Agent

Table 2.
First Choice of Agent by Anesthesia Care Provider

Agent	*Retrospective Chart Review*		*Provider Survey*	
	Number	Percent	Number	Percent
Induction Agents:				
Propofol	58	75	17	90
Sodium Thiopental	19	25	2	10
Total	**77**	**100**	**19**	**100**
Neuromuscular Blocking Agents:				
Succinylcholine	76	99	16	85
Vecuronium	1	1	1	5
Rocuronium	0	0	2	10
Total	**77**	**100**	**19**	**100**

Anesthesia providers indicated the physical status of the patient as the first consideration for their choice of an induction agent, followed by the incidence of side effects produced by the drug and duration of action of the drug. The cost of the induction agent received a low priority being ranked an average of 7 on a scale of 1 (highest influence) to 10 (lowest influence) by 77% of the providers (Figure 10). Cost center manager influence averaged 8.5 on this scale. There was no significant correlation between years of anesthesia practice and factors influencing provider's choice of induction agent.

Succinylcholine was the neuromuscular relaxation agent of choice (Table 2). It ranked first by 85% of the anesthesia care providers. Rocuronium was ranked number

one by 10% and vecuronium by only 5%. Physical status of the patient was the primary consideration. Duration of action of the medication and the presence of side effects ranked second and third respectively. Eight of 15 providers gave moderate consideration to the length of the case (ranked 5), and less concern for the cost of the drug (mean 6.6) or influence of the cost center manager (mean 7.6) (Figure 11).

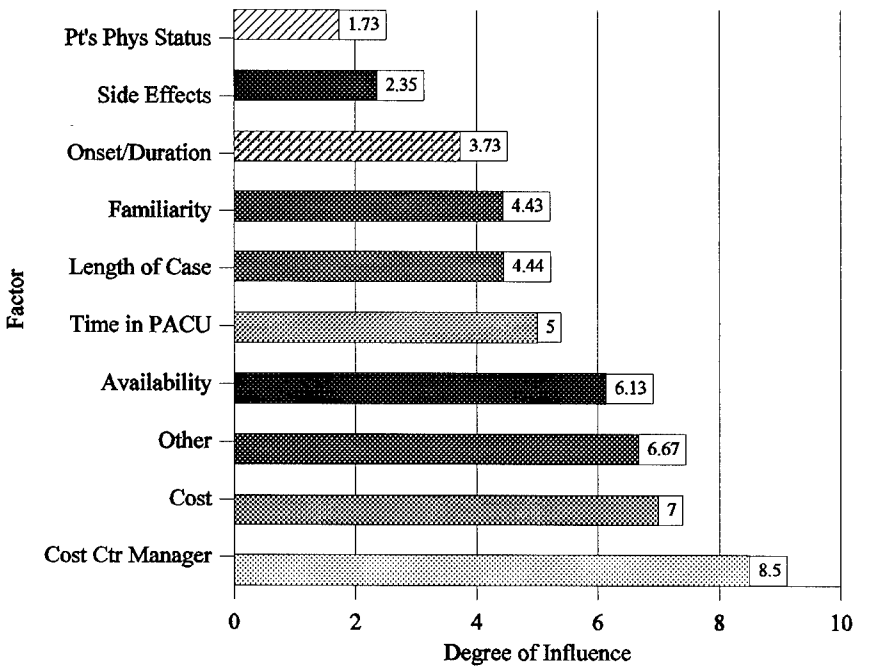

Figure 10.
Factors Affecting Choice of Induction Agents (In Rank Order of Degree of Influence)

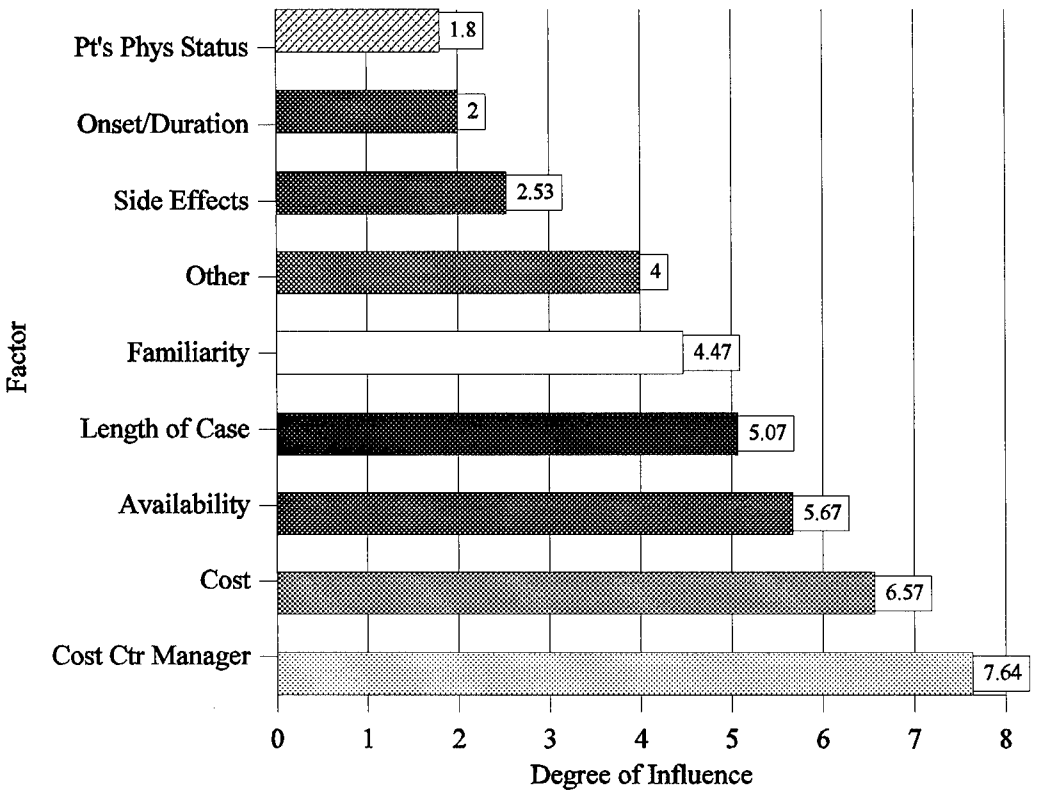

Figure 11.
Factors Affecting Choice of Neuromuscular Relaxation Agents (In Rank Order of Degree of Influence)

Cost Data

Anesthesia providers estimated the cost of sodium thiopental to be $0.20 to $5.00 with a mean of $1.99. The cost was not known to 20% of the providers. The estimated cost of propofol ranged from $1.50 to $20.00 with a mean of $9.98. The cost was unknown to19% of the providers (Table 3).

Atracurium was given an estimated cost of $2.50 to $401.00. The mean estimated cost was $43.20 with a standard deviation of 112.9. The majority of the estimates ranged from $2.50 to $25.00 with a mean estimate of $10.68. The cost of atracurium was unknown to 25% of the providers. Rocuronium's cost was estimated from $5.00 to $15.32 with a mean of $10.06 and standard deviation of 5.0. The cost of rocuronium was unknown to 26.7% of the providers. The range of estimated costs for succinylcholine was much narrower with estimates of $0.30 to $3.00 with a mean of $0.84 and standard deviation of 0.76. Four of the fifteen (26.7%) providers were not aware of the cost of succinylcholine. Vecuronium was given an estimated cost of $0.99 to $199.00. The mean cost was $23.92 with a standard deviation of 55.44. The mean dropped to $8.02 with the exclusion of the one high estimate. Vecuronium's cost was unknown to 25% of the providers. With the exception of the mean estimated cost for atracurium, the mean estimated drug costs did not differ greatly from published drug costs (Table 3, Table 4).

The average weight of the patient was 77.64 kilograms. Based on the average weight of the patient and the average doses of neuromuscular relaxation agent used, the cost to the study hospital for neuromuscular blockade for intubation was $0.38 for a

100mg (5cc) ampule of succinylcholine and $15.13 for a 10mg (10cc) vial of vecuronium. Induction cost the hospital $10.78 for a 200mg (20cc) ampule of propofol and $2.00 for a 500mg (20cc) syringe of sodium thiopental (Table 4).

Table 3.
Estimated Cost versus Actual Cost of Selected Anesthetic Agents (in dollars)

Agent	*Mean Estimated Cost (Range)*	*Actual Cost to Study Hospital*
Propofol 200mg/20cc	9.98 (1.50 -20.00)	10.78
Sodium Thiopental 500mg/20cc	1.99 (0.20 - 5.00)	2.00
Succinylcholine 200mg/10cc	0.84 (0.30 - 3.00)	0.38
Atracurium 50mg/5cc	43.20 (2.50 - 401.00)	15.47
Vecuronium 10mg/10cc	23.92 (0.99 - 199.00)	15.13
Rocuronium 50mg/5cc	10.06 (4.00 - 15.32)	15.33

Post anesthesia care unit (PACU) costs at the study hospital were $6.49 per minute for outpatients and $9.74 per minute for inpatients with an average cost of $8.12 per minute. With the mean PACU time of 110.5 minutes for patients receiving sodium thiopental, 92.3 minutes for patients receiving propofol, and 96.8 minutes overall, the

Table 4.
Cost of Selected Induction and Neuromuscular Blocking Agents (in dollars) to the Study Hospital

Amount	*Cost*
Induction Agents:	
Propofol	
200mg/20cc	10.78
500mg/50cc	29.16
Sodium Thiopental	
200mg/20cc	2.00
Neuromuscular Blocking Agents:	
Succinylcholine	
200mg/10cc	0.38
Atracurium	
50mg/5cc	15.47
Vecuronium	
10mg/10cc	15.13
20mg/20cc	29.61
Rocuronium	
50mg/5cc	15.33
100mg/10cc	29.42

cost for PACU stay was an average of $897.26, $749.48, and $786.02 respectively.

The cost for the use of propofol and succinylcholine was $11.16, sodium thiopental and succinylcholine $2.38, propofol and vecuronium $25.91, and sodium thiopental and vecuronium $17.13. Even though the initial costs of using propofol for induction was higher than using sodium thiopental ($10.78 versus $2.00), the overall cost with the use of propofol was significantly lower with respect to the lower time required for PACU care. The cost of using propofol combined with the average time in the

PACU was $760.64 versus $899.64 when sodium thiopental was used (Table 5). No conclusions about the differences in PACU time could be made concerning the use of the different neuromuscular relaxation agents as 99% of the patients received succinylcholine.

Table 5.
Cost of Anesthetic Agent and PACU Time (in dollars)

Anesthetic Agent	*Average Cost of Anesthetic Agent**	*Average PACU Cost***	*Average Overall Cost****
Propofol & Succinylcholine	11.16	749.48	760.64
Sodium Thiopental & Succinylcholine	2.38	897.26	899.64
Propofol & Vecuronium	25.91	749.48	775.39
Sodium Thiopental & Vecuronium	17.13	897.26	914.39

Note. No significant differences were noted in PACU time with the use of succinylcholine versus the use of vecuronium.
*Average cost of anesthetic agent based on an average dose of propofol of 2.5mg/kg, an average dose of sodium thiopental of 4.7mg/kg, an average dose of succinylcholine of 0.74mg/kg, and an average dose of 0.13mg/kg of vecuronium given to a patient with an average weight of 77.64kg.
**The average PACU cost is based on an average PACU stay of 92.3 minutes for patients receiving propofol and an average PACU stay of 110.5 minutes for patients receiving sodium thiopental using an average PACU cost of $8.12/minute.
*** Average cost of anesthetic agents added to average PACU cost.

Other induction agents were etomidate with a cost of $16.11 for 20mg/10cc and a versed/narcotic induction with a cost of $3.75 for a 2mg vial of versed and $0.75 for a 2ml ampule of fentanyl. Other neuromuscular relaxation agents included in the study were rocuronium ($15.33 for 5cc) and atracurium ($15.47 for 5cc). Other neuromuscular relaxation agents were nimbex ($14.57 for 10cc) and mivacurium ($13.60 for 10cc). The cost of using either of these alternative combinations would be closely related to the calculated costs using a propofol and vecuronium combination previously discussed.

CHAPTER FIVE : CONCLUSIONS

Cost and cost containment are major issues in today's health care industry. It is vitally important to know providers' choices of anesthetic agents and the cost of their choices. This study set out to determine the factors that influenced tha choice of agents for induction and neuromuscular relaxation for intubation using Tuman' s (1995) model of gathering outcome data to support the use of current anesthetic practices. In addition, the study sought to answer questions related to the cost effectiveness of selected practices. Propofol was chosen as the induction agent and succinylcholine as the neuromuscular relaxation agent by the majority of anesthesia providers for ASA I and ASA II patients. The choice of induction agent was influenced most often by the physical status of the patient, the incidence of side effects produced by the drug, and duration of action of the agent. The choice of neuromuscular relaxation agent was determined by the physical status of the patient, the duration of action of the medication, and the presence of side effects.

The choices for induction agent and neuromuscular relaxation agent were consistent with findings by Stanek (1996). However, Horrow and Rosenberg (1994) found sodium thiopental to be the most frequently used induction agent. They found succinylcholine to be among the most frequently used neuromuscular relaxation agents (along with pancuronium and vecuronium).

Johnstone and Jozefczyk (1994) attempted to address anesthesia drug costs in their study by educating the staff on the costs of ten of the most expensive drugs including atracurium, vecuronium, and propofol. Following the education process there was a brief decrease in the use of the more expensive drugs. Eventually, the use of these

drugs rose above pre-education levels of use. In the study by Horrow and Rosenberg (1994) which placed price stickers on anesthesia drugs no impact on the pattern of use of these drugs occurred.

Neither the cost of an anesthetic drug nor cost center manager influence were considered a high priority in this study. Cost as a factor in choice ranked from six to nine for induction (mean 7) and neuromuscular relaxation agents (mean 6.6). Cost center manager influence ranked six to ten for induction agents (mean 8.5) and neuromuscular relaxation agents (mean 7.6). Overall, the anesthesia care providers estimated costs for the various anesthesia drugs close to the actual cost to the hospital (Table 3). The estimated costs for atracurium and vecuronium were significantly high due to the estimates of one anesthesia care provider. When those values were excluded, the estimated costs were within $5.00 to $7.00 of the actual costs of the drugs. Two providers gave estimated costs that were the same as the costs to the hospital for the anesthesia drugs. These providers may have been familiar with these drug costs or they may have obtained the cost of these drugs from the hospital's pharmacy.

The cost of using an anesthetic drug involves not only its actual cost for acquisition, but also the cost of its impact on PACU time. Medications with a high incidence of postoperative complications contribute to excess post anesthesia care unit stay. Eddy (Jan 19, 1990a) suggested making judgements based on comparison of benefits gained in relation to resources consumed to determine what choices produce the highest yield.

Consistent with findings of Weightman and Zacharias (1987), in this study patients who received propofol had a faster recovery and shorter PACU stay than those who

received sodium thiopental (Figure 6). The overall incidence of postoperative complications was lower with the use of propofol (Figure 8). There was also a higher frequency of patients who experienced no postoperative complications following the use of propofol compared to sodium thiopental (Figure 9).

Geniton (1992) and Katzung (1995) eluded to propofol's antiemetic properties. The incidence of postoperative nausea and vomiting with propofol (12%) compared to sodium thiopental (10.5%) was similar (Figure 8). This finding may have been affected by the female gender and the high incidence of gynecological surgeries (Figure 2). Singh et al. (1994) reported less incidence of postoperative shivering with propofol when compared to sodium thiopental. Shivering occurred in three patients who received propofol. Shivering was not present in patients who received sodium thiopental. Decreased temperature was noted in two of nineteen (10.5%) patients who received sodium thiopental and seven of fifty-eight (12%) patients who received propofol (Figure 8).

Many variables that are significant in the development of postoperative complications and subsequent post anesthesia care unit (PACU) stay were not controlled in this study. These results serve only as a starting point for examining the effect of the use of propofol versus sodium thiopental on recovery and PACU time.

Future studies should be conducted involving a more detailed cost analysis concerning the use of induction and/or neuromuscular relaxation agents. A study controlling for extraneous variables should be performed to demonstrate a more meaningful causal relationship between use of induction agent and incidence of postoperative complications or between use of induction agent and time spent in the

PACU. A study could be conducted after educating the anesthesia provider staff about the results of this study and the overall cost savings with the use of propofol to see if the use of propofol increased.

This study serves to enlighten anesthesia providers on the choices made in the use of anesthesia drugs, the factors contributing to these choices, the cost of the anesthesia drugs chosen, and the effect of these choices on recovery. We must be continually aware of the concept that an initial low cost for a drug does not always equal an overall low cost for the care of the patient.

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APPENDICES

Appendix A. Anesthesia Care Provider Questionnaire for Choice of Intravenous Anesthetic Induction Agent and Neuromuscular Relaxant for Intubation

Appendix B. Questionnaire for Retrospective Chart Review for Choice of Intravenous Anesthetic Induction Agent and Neuromuscular Relaxant for Intubation

Appendix C. Subject Cover Letter

Appendix D. Agency Cover Letter/Consent Form

Appendix A

ANESTHESIA CARE PROVIDER QUESTIONNAIRE FOR CHOICE OF INTRAVENOUS ANESTHETIC INDUCTION AGENT AND NEUROMUSCULAR RELAXANT FOR INTUBATION

1. Gender: 1. Male _____ 2. Female_____

2. Age:
   1. 30 - 39_____
   2. 40 - 49_____
   3. 50 - 59_____
   4. 60 or older_____

3. Length of anesthesia practice: _____ (years)

4. Please select and rank which intravenous induction agent(s) you prefer for routine induction in ASA I and ASA II patients. The number 1 indicates the highest priority.
   1. Sodium thiopental_____
   2. Propofol_____
   3. Other (please specify)_____

5. Please rank in order of importance which factors influence your choice of intravenous induction agent. The number 1 indicates the highest priority.
   1. Availability_____
   2. Cost_____
   3. Familiarity with the drug_____
   4. Lower frequency of adverse/side effects_____
   5. Patient's physical status or presence of underlying disease_____
   6. Amount of time patient remains in the recovery room_____
   7. Onset and duration of action_____
   8. Strongly encouraged by cost center managers_____
   9. Length of case_____
   10. Other (please specify)_____

6. Please select and rank which neuromuscular relaxation agent(s) you prefer for routine intubation in ASA I and ASA II patients. The number 1 indicates the highest priority.
   1. Atracurium _____
   2. Succinylcholine_____
   3. Rocuronium_____
   4. Vecuronium____
   5. Other (please specify)_____

7. Please rank the following choices in the order in which they influence your choice of neuromuscular relaxation agents for intubation. The number 1 indicates the highest priority.

1. Availability_____
2. Cost_____
3. Familiarity with the drug_____
4. Lower frequency of adverse/side effects_____
5. Patient's physical status or presence of underlying disease_____
6. Onset and duration of action_____
7. Strongly encouraged by cost center manager_____
8. Length of case_____
9. Other (please specify)_____

8. Indicate the cost (in dollars) of the following induction agents:
    1. Sodium thiopental 20 cc (25mg/cc)____
    2. Propofol 20cc (10mg/cc)____

9. Indicate the cost (in dollars) of the following neuromuscular blocking agents:
    1. Atracurium 5cc (10mg/cc)____
    2. Succinylcholine 10cc (20mg/cc)____
    3. Rocuronium 5cc (10mg/cc)____
    4. Vecuronium 10cc (1mg/cc)____

Appendix B

QUESTIONNAIRE FOR RETROSPECTIVE CHART REVIEW FOR CHOICE OF INTRAVENOUS INDUCTION ANESTHETIC INDUCTION AGENT AND NEUROMUSCULAR RELAXANT FOR INTUBATION

1. Patient's hospital ID number:_____

2. Patient's Age: Weight:_____
    1. 18 - 27 _____
    2. 28 - 37_____
    3. 38 - 47_____
    4. 48 - 57_____
    5. 58 - 65_____

3. Gender: 1. Male_____ 2. Female_____

4. ASA classification: 1. ASA I_____

    2. ASA II_____

5. Surgical category:
    1. GYNECOLOGIC_____
    2. OBSTETRIC_____
    3. RESPIRATORY_____
    4. CARDIAC_____
    5. NEUROLOGIC_____
    6. ABDOMINAL_____
    7. EAR, NOSE, THROAT (ENT)_____
    8. EYE_____
    9. ORTHOPEDIC_____
    10. UROLOGIC_____
    11. GASTROINTESTINAL_____
    12. OTHER (specify)_____

6. Intravenous agent used for induction of general anesthesia:
    1. Sodium thiopental_____ dose (mgs.)_____
    2. Propofol_____ dose (mgs.)_____
    3. Other (specify)_____ dose (mgs.)_____

7. Agent used for neuromuscular relaxation for intubation:
    1. Succinylcholine_____ dose (mgs.)_____
    2. Atracurium_____ dose (mgs.)_____
    3. Rocuronium_____ dose (mgs.)_____
    4. Vecuronium____ dose (mgs.)____
    5. Other (specify)_____ dose (mgs.)_____

8. Time spent in the recovery room (in minutes)_____

9. Postoperative complications:
    1. Nausea/vomiting____
    2. Pain____
    3. Shivering____
    4. Respiratory difficulty____
    5. Other (specify)____

Appendix C

SUBJECT COVER LETTER

Dear _____,

You are being asked to participate in a research study concerning the choice of selected intravenous anesthetic induction agents and agents used for neuromuscular blockade for intubation. I want to learn the freqency with which the various agents are chosen for use and whether or not cost plays a role. You are being asked to participate in the study because you meet the criteria of being a licensed anesthesia care provider.

If you decide to participate, I would ask that you complete the enclosed questionnaire and return it within thirty (30) days in the self-addressed, stamped envelope provided. The questionnaire requires approximately 15 to 30 minutes of your time to complete. This is the only procedure that your participation warrants.

It is hoped that you will benefit from your participation in the study by way of the value placed on your opinions as well as the feeling received from knowing that you have made your preference known. I do not guarantee that you will benefit from this study.

There are no monetary incentives offered for your participation in this study. However, I would appreciate your participation.

Everything I learn about you in the study will be confidential. If I publish the results of the study in a scientific journal or book, you will not be identified in any way. All data will be presented in the aggregate. Surveys will be destroyed six (6) months after completion of the research study.

Your decision to participate in the study is voluntary. You are free to decide not to participate in the study or to withdraw from the study at any time. If you decide not to participate or to withdraw at any time, it will not affect future relationships at the

Uniformed Services University of the Health Sciences in Bethesda.

If you have any questions now, feel free to ask me. If you have additional questions later, Capt. Lorene R. Anderson can be reached at (301) 295 - 6565 (work) or (301) 513 - 9694 (home). The Uniformed Services University committee that reviews research with regards to human rights (Institutional Review Board) will answer any questions about your rights as a research subject (301 - 295 - 3303).

Study results will be available upon request by contacting the researcher.

This is your personal copy of this letter.

YOUR RETURNED QUESTIONNAIRE INDICATES THAT YOU HAVE DECIDED TO PARTICIPATE IN THIS RESEARCH STUDY AND THAT YOU HAVE READ AND UNDERSTAND THE INFORMATION GIVEN ABOVE AND EXPLAINED TO YOU.

Appendix D

AGENCY COVER LETTER/CONSENT FORM

Dear Director of Anesthesia,

Greater Southeast Community Hospital is being asked to participate in a research study involving the frequency of use and cost of selected intravenous anesthetic induction agents and neuromuscular agents for relaxation during intubation. I want to learn which agents are being used and whether or not cost plays a role. Subjects for the study will be all licensed anesthesia care providers employed by the hospital.

Subjects will be asked to contribute 15 to 30 minutes of their off duty time to completing the questionnaire. There are no guaranteed benefits or incentives offered.

Everything I learn about your agency in the study will be confidential. If I publish the results of the study in a scientific journal or book, your agency will not be identified in any way. All data will be reported in the aggregate. Information identifying the hospital will be kept in a locked file cabinet accessible to the researcher only. Surveys will be destroyed six (6) months after completion of the research study.

Your decision to participate in the study is voluntary. You are free to decide not to participate in the study or to withdraw from the study at any time.

If you have any questions now, feel free to ask me. If you have additional questions later, Capt. Lorene R. Anderson can be reached at (301) 295 - 6565 (work) or (301) 513- 9694 (home). The Uniformed Services University of the Health Sciences committee that reviews research with regards to human rights (Institutional Review Board) will answer any questions about your rights as a research participant (301 - 295 - 3303).

Study results will be forwarded to the agency upon completion of the study.

You will be given a copy of this consent to keep for your records.

YOUR SIGNATURE ON THIS CONSENT INDICATES THAT YOU HAVE DECIDED TO PARTICIPATE IN THIS RESEARCH STUDY AND THAT YOU HAVE READ AND UNDERSTAND THE INFORMATION GIVEN ABOVE.

_____

Signature of agency representative

_____

Signature of Witness

_____

Signature of Investigator

_____/_____

Date Time